

VERIFICATION OF "PROBABILITY" FIRE-WEATHER FORECASTS

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ABSTRACT

Probability terms, especially in relation to precipitation occurrence, were incorporated in fire-weather forecasts on a trial basis in the Chicago District during the 1952 fire-weather seasons. These forecasts were verified in an attempt to determine whether or not such subjective estimates of probability were feasible. Results show that forecasters have some skill in assessing the probability of the occurrence of precipitation especially for the first 30 hours.

INTRODUCTION

In the job of fire control the forester must make plans and decisions on the basis of weather forecasts. It frequently is helpful to him to know the degree of confidence that the forecaster has in the forecast of some of the weather elements. If, for example, the forecaster made a categorical prediction of rain every time he determined that there was more than a 50 percent chance of occurrence, the forester many times would fail to make the proper suppression plans. On the other hand, if the forecaster's estimate of the probability of rain is made known to the forester, the latter can weigh his chances of getting rain against the probable consequences if no rain should occur in any particular situation and then determine the suppression action to be taken.

Uses of probability forecasts in business, industry, agriculture, and aviation have been discussed by Brier [1] and Thompson [2], [3].

Starting in 1952, at the request of the U. S. Forest Service, the Chicago Weather Bureau Forecast Center used probability terms in fire-weather forecasts, particularly with respect to the occurrence of precipitation. The qualifying terms for this purpose were defined as follows:

Chance of precipitation

Unqualified.....	approximately 80 to 100 percent.
Probable.....	approximately 60 to 80 percent.
Possible.....	approximately 40 to 60 percent.
Chance of.....	less than 40 percent. (The forecasters state that the lower limit they had in mind when using the term "chance" was about 10 percent.)

Provision was also made for indicating extreme values of minimum humidity or maximum wind velocity that could occur in particular situations by use of the terms "possibly as low as" for relative humidity, and "possibly as high as" for wind velocity. It was understood that the probability of occurrence of the extreme values was considered to be less than 50 percent.

Fire-weather forecasts in this district are made for fire-weather forecast zones of which there are 6 in northern and central Minnesota, 4 in northern and central Wisconsin, 6 in Michigan, and 1 in the southern portion of each of the States of Illinois, Indiana, and Ohio. Most of the forecasts were made during the spring and fall months and only a few during the summer months. The estimates of probability in these forecasts were made subjectively.

At the close of the 1952 fire-weather seasons the forestry agencies were requested to comment on the use of probability terms and advise whether or not they wished the practice to continue. Without exception, the replies were in the affirmative. It was then decided that an attempt be made to verify the forecasts for the year to determine if the forecaster had any ability to assess subjectively the probability of occurrence, especially of precipitation.

The use of probability statements in forecasting is certainly not new, since the need for qualified forecasts for use by business and industry has been recognized for some time [1, 2]. Confidence factors, or expressions of probability, are used in forecasts arrived at through various objective forecast methods that have been developed [2, 4, 5]. Williams [6] describes a trial of the use of confidence factors by forecasters at Salt Lake City in subjective forecasts and illustrates the feasibility of their use. Our use differs in several respects from that which he describes. Our forecasts were for zones instead of just the local station, and nearly all zones are some distance from the forecast center. In addition the top category of his confidence factors was 10, or 100 percent confidence, whereas in our case the unqualified statement was meant to indicate 80 to 100 percent confidence. We did not attempt to state a confidence factor for the no-rain forecasts, though the absence of a qualified rain statement could be interpreted to mean 90 to 100 percent confidence in no rain. In most respects our trial was not as rigidly controlled as was the one Williams describes.

METHOD OF VERIFICATION FOR PRECIPITATION

One of the problems encountered in attempting to verify the forecast lay in the fact that observation periods did not coincide with the forecast periods. The observations from all stations in the fire-weather forecast zones were used, including regular fire-weather stations and all Interstate Airway Communications Stations (INSACS) and Weather Bureau station observations which are plotted on our 6-hourly district maps. By definition, the fire-weather forecast periods are as follows:

Tonight..... time of release to sunrise tomorrow
(time of release 1:30-2:00 p. m. cst)
Tomorrow..... sunrise to sunset tomorrow
Next day..... sunset tomorrow to sunset the next day

Precipitation measurements at Weather Bureau and INSAC stations are, of course, taken at 0030 cst and each 6 hours thereafter. Precipitation measurements at fire-weather stations are taken once daily for a 24-hour period ending at 0800 cst. Where times of beginning and ending were indicated there was little difficulty, but perhaps as many as half of the fire-weather stations did not indicate the times.

To resolve the problem of time periods, the fire-weather forecast periods were considered as follows: "tonight" was considered as 1830 cst to 0630 cst, "tomorrow" as 0630 cst to 1830 cst, and "next day" as 1830 cst tomorrow to 1830 cst the next day. This no doubt caused some loss, especially on the period "tonight", but was thought to be the best way of proceeding. The precipitation measurements at INSAC and Weather Bureau stations for these periods were taken from the 6-hourly district maps. Where fire-weather stations had indicated the times of beginning and ending, the precipitation could be placed in the proper period. In those cases where the time was not indicated, the precipitation was placed in the proper period as accurately as possible by careful inspection of the 6-hourly district maps. At the time of carrying out this operation, the forecast for the period was not known so that there could be no bias in favor of the forecast.

In verifying precipitation, a trace was considered as "no rain", since in fire-weather usage it is disregarded on the danger meter. The number of reporting stations in each fire-weather forecast zone in most cases was three to five, but varied from one to eight. If 0.01 in. or more of precipitation was reported in the period at one or more of the stations in the zone, it verified a "rain" forecast and broke a "no rain" forecast. All forecasts calling for showers, even though "scattered" or "widely scattered", were classed as "rain" forecasts.

From the above it will be noted that there could be no instances where the verification worked "both ways," that is verified either a "rain" or "no rain" forecast. In this respect, the verification is much more rigid than that used for our local and state forecasts.

TABLE 1.—Verification of "rain" forecasts, Chicago district fire-weather forecast zones, 1952, seasons

	Unqualified	Probable	Possible	Chance
Tonight				
Number of forecasts.....	342	41	29	38
Percentage of periods with rain reported....	67.3	63.4	44.8	13.2
Tomorrow				
Number of forecasts.....	228	43	55	43
Percentage of periods with rain reported....	49.1	58.1	41.8	16.3
Next day				
Number of forecasts.....	117	80	156	27
Percentage of periods with rain reported....	55.6	56.3	36.5	47.7

RESULTS

Table 1 gives the verification figures for the "rain" forecasts for the three forecast periods.

Certainly the verification figures are lower than one would like to have them, but, nevertheless, it appears as though the forecasters have some ability to assess the probability of the occurrence of precipitation. This ability is greatest for the first period and decreases as the time period is extended. The only figures that do not agree in general are for the unqualified and probable forecasts for "tomorrow," and for this there is no apparent explanation. It should be noted, however, that for the "tonight" and "tomorrow" forecasts there are many times as many in the unqualified classification as in any other. This is at least partly due to the fact that on 1 day per week and during periods when the fire-weather supervisor was on inspection trips or on a district shift, the forecasts were made by one of a number of forecasters other than the fire-weather supervisor. Since many of these forecasters made fire-weather forecasts only infrequently, they were not as prone to use the qualifying terms as was the fire-weather forecaster. It is quite certain that if a real attempt had been made to assess the probabilities with every forecast, there would have been fewer forecasts in the unqualified category and more with qualifying terms. This should have resulted in better verification for the unqualified forecasts and perhaps poorer verification for the other groups.

Table 2 gives the verification of all "rain" forecasts combined without respect to the assigned probability, and excluding "chance." The "chance" forecast cannot be considered a "rain" forecast since by definition we are indicating less than 40 percent chance of rain.

TABLE 2.—Verification of all "rain" forecasts combined without respect to assigned probability and excluding "chance," Chicago district fire-weather forecast zones, 1952 seasons

	Tonight	Tomorrow	Next day
Number of forecasts.....	412	326	353
Percentage of periods with rain reported....	65.3	49.1	47.3

TABLE 3.—Verification of "no rain" forecasts, Chicago district fire-weather forecast zones, 1952 seasons

	Tonight	Tomorrow	Next day
Number of forecasts.....	1,347	1,428	1,397
Percent correct.....	85.7	84.6	65.8

To provide a more complete picture, the "no rain" forecasts for the 1952 fire-weather seasons were also verified. These results are given in table 3. From the results it is apparent that even on "fair" forecasts the verification drops off abruptly as the forecast is extended into the third day.

The verification shows that there is little distinction between the "chance" forecasts and the "no rain" forecasts, and between the "rain" forecasts and the "rain probable" forecasts. Combining them, but keeping the "rain possible" forecasts separate from the others, the results given in table 4 were obtained.

TABLE 4.—Verification of "rain" (unqualified and probable), "rain possible," and "no rain" (chance and no rain) forecasts, Chicago district fire-weather forecast zones, 1952 seasons

	Rain forecast	Rain possible	No rain forecast	Total
Tonight				
Rain observed.....	256	13	197	466
No rain observed.....	127	16	1,188	1,331
Total.....	383	29	1,385	1,797
Percent correct.....	66.8		85.8	
Tomorrow				
Rain observed.....	137	23	227	387
No rain observed.....	134	32	1,244	1,410
Total.....	271	55	1,471	1,797
Percent correct.....	50.6		84.6	
Next day				
Rain observed.....	110	57	491	658
No rain observed.....	87	99	953	1,139
Total.....	197	156	1,444	1,797
Percent correct.....	55.8		66.0	

The skill scores for all forecasts, with "chance" again verified as "no rain," are given in table 5. The skill for forecasting precipitation the third day ahead is low compared to the first two periods. Perhaps the only excuse for routinely making a forecast for the third day lies in the fact that the forecaster has an opportunity to attempt to correct the third day's forecast on the second day. Very likely in portions of the country where weather changes are less frequent than in this district, verification for the third day is better. Even in this district on occasion the weather regime is such that a forecast can be made with a rather high degree of confidence for three, or even four, days ahead. But this cannot be done routinely. The only important criticisms of fire-weather forecasts heard in this district have concerned the forecast for the third day.

TABLE 5.—Skill scores for all forecasts, with "chance" verified as "no rain," Chicago district fire-weather forecast zones, 1952 seasons

	Tonight	Tomorrow	Next day
Skill score.....	.488	.314	.101

HUMIDITY VERIFICATION

There were only a few cases in which the term "possibly as low as" was used in connection with minimum humidity predictions in the fire-weather forecasts for 1952. When used, it was in a manner such as this—"Humidity tomorrow 30-40 but possibly as low as 20-30." In verifying humidities, certain problems are encountered since the minimum humidities are not observed. Instead, readings are taken at 0800, 1200 and 1630 CST. In attempting to judge the forecasts, the lowest humidity at any station in the forecast zone at any observation during the day was used. The results are given in table 6.

TABLE 6.—Verification of qualified humidity forecasts, Chicago district fire-weather forecast zones, 1952 seasons

Forecast %	Number of forecasts	Number of times lowest observed humidities were in ranges
20-30 but possibly as low as 10-20 (or 15).....	36	10-19 3 20-29 24 30 or higher 9
30-40 but possibly as low as 20-30.....	32	10-19 5 20-29 9 30-39 14 40 or higher 4
40-50 but possibly as low as 30-40.....	17	20-29 1 30-39 2 40-49 2 50 or higher 12

CONCLUSIONS

From the verification of fire-weather forecasts for the 1952 seasons it is believed the following conclusions can be drawn regarding probability terms:

1. The forecasters show some skill in assessing the probability of the occurrence of precipitation especially for the periods "tonight" and "tomorrow." It is felt therefore, that forecasters are justified in continuing the practice.
2. Probability terms should be used even more frequently than they were during this test period. An unqualified forecast of precipitation should be made only in cases of extremely high confidence.
3. The forecasters have little skill in forecasting precipitation for the third day ahead. Therefore nearly all precipitation forecasts for that day should contain a qualifying term. The prediction for the third day should be termed an "outlook" rather than a "forecast." The suggestion has also been made that, especially when the timing of precipitation is uncertain, a longer period such as an outlook for the third and fourth day be used.
4. Because of the small number of times that a probability phrase was used in the humidity forecast, no definite conclusions can be drawn. The practice, nevertheless, is being continued.

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